

REMARKS

Claim 10 is amended to indicate that the heat treatment of step (b) is conducted in an atmosphere that is sufficiently carburizing to permit the carbon content of the tungsten carbide to approach the theoretical. No new matter is added; support for this amendment can be found on page 9, lines 2-3 of the specification.

New Claim 16 is added. Claim 16 is directed to the process of Claim 10 (without the above amendment), with additional language indicating the nature of the tungsten carbide produced by the claimed process, as specified by the relationship between coherence length and lattice strain in Formula I. This formula is shown at page 6, line 4 of the specification.

Rejections under 35 U.S.C. §103

Claims 10-14 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Alonso et al., Int. J. Min. Proc. 20 (1987), pp 137-151, in view of Polizotti et al., U. S. 4,851,041 and Felten et al., FR 2 294 133. Applicants respectfully traverse this rejection in view of the amendments above and new Claim 16.

As amended, Claim 10 is directed to a process of making a tungsten carbide, the process occurring in two steps:

a) carburizing the starting material at a temperature ranging from 850° to 950°, in the presence of a carburizing gas phase, the carburizing gas phase comprising a mixture of CO and CO₂ and having a CO₂ content which is above the Boudouard equilibrium content corresponding to the carburization temperature, and having a carbon activity ranging from 0.4 to less than 1; and

(b) heat treating the tungsten carbide formed in step (a) at a temperature ranging from 1,150°C to 1,800°C, and at a carburizing atmosphere sufficient for the carbon content of the tungsten carbide to approach the theoretical, thereby forming tungsten carbide.

As now reflected in Claim 10, the tungsten carbide of the present invention is subjected to a heat treatment step in a carburizing atmosphere that increases the carbon content of the tungsten carbide. Examples 2 and 3 demonstrate that the carbon content of the tungsten carbide increases after the heat treatment step. The

heat treatment step stabilizes the tungsten carbide against grain growth in hard metal production.

Thus, the carburizing atmosphere of the heat treatment step is (and must be) different from the carburizing atmosphere of step (a). In fact, the carbon activity is between 1 and a value corresponding to the equilibrium between W_2C and WC in this step of the process. As would be recognized by one skilled in the art, and as exemplified by the formula at page 3, line 15 in the specification, carbon activity falls for the same ratio of CO_2/CO as the temperature increases. Therefore, at the increased temperature of the heat treatment step, if the atmosphere was not more carburizing than in the previous step, a reduction in carbon content of the tungsten carbide would occur. This is obviously not the case, as shown in the data presented in the examples.

Claim 16 is directed to a process of making a tungsten carbide, the process occurring in two steps:

a) carburizing the starting material at a temperature ranging from 850° to 950° , in the presence of a carburizing gas phase, the carburizing gas phase comprising a mixture of CO and CO_2 and having a CO_2 content which is above the Boudouard equilibrium content corresponding to the carburization temperature, and having a carbon activity ranging from 0.4 to less than 1; and

(b) heat treating the tungsten carbide formed in step (a) at a temperature ranging from $1,150^\circ C$ to $1,800^\circ C$, thereby forming tungsten carbide, wherein said tungsten carbide is characterized by a relationship between coherence length x and lattice strain y according to Formula (I): $y < (-4.06 * 10^{-4} \text{ nm}^{-1} * x + 0.113)\%$.

As explained above, the carburizing atmosphere in the heat treatment step is different from the carburizing atmosphere in the heat treatment step, and increases the carbon content of the tungsten carbide produced by the claimed process. The tungsten carbide of the present invention has improved properties, as compared to prior art compositions.

Alonso et al. disclose the carburization of tungsten trioxide with CO or a CO_2/CO mixture, wherein the mixtures described have very low carbon activities. It is conceded in the Office Action that Alonso does not teach the specific carbon activity recited in step (a) of Claim 10, 0.4 to less than 1.0, and that Alonso does not teach a

heat treatment step. In fact, Alonso et al. teach away from the use of CO₂/CO mixtures; on p. 150, second paragraph of the Alonso article the authors conclude that carburization of tungsten trioxide is carried out best solely with carbon monoxide. Thus, Alonso cannot be said to teach “the invention substantially as claimed”, as asserted in the Office Action. A prior art reference must be considered in its entirety, i.e., as a whole, including portions that would lead away from the claimed invention. *W.L. Gore & Associates, Inc. v. Garlock, Inc.*, 721 F.2d 1540, 220 USPQ 303 (Fed. Cir. 1983), *cert. denied*, 469 U.S. 851 (1984); MPEP 2141.02.

Alonso does not teach a heat treatment step in a carburizing atmosphere (Claim 10), and does not teach a tungsten carbide product having the recited properties (Claim 16). Since no heat treatment is described in Alonso et al., the tungsten carbide described therein cannot inherently possess the property presently claimed in Claim 16.

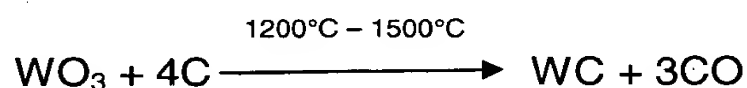
Polizotti is cited as providing the rationale for selecting the claimed carbon activity range. Polizotti discloses gas phase carburization of a W- and Co-containing intermediate into a Co- and WC-containing composite with two distinct phases. An organometallic material is used as a starting material, which is then pyrolysed *in situ* before it is treated with gaseous CO and CO₂.

Polizotti is able to achieve carburization of the W into tungsten carbide in a short period of time, at lower temperatures, for at least two reasons. First, as explained in the patent beginning at column 3, line 67 – column 4, line 5, column 2, lines 52-54 and column 4, lines 60-65, the high surface area stemming from the decomposition of the W- and Co-containing complex oxide with organic ligands provides high reactivity, so that at low temperatures (below 850°C) reactivity is high enough to carburize the W. Second, and as would be understood by one skilled in the art, finely divided particles of iron group metals have a catalytic effect on achievement of thermodynamic equilibrium between gas phase species and also on equilibrium between gas and solid phase species. The presence of cobalt, therefore, also contributes to Polizotti's ability to use lower temperatures.

Polizotti does not remotely teach or suggest the heat treatment step of the presently claimed process in Claim 10 or Claim 16. It would not be feasible to heat treat the composites of Polizotti at temperatures higher than 1240°-1280°C because

the ternary eutectic temperature for W-Co-C lies in this area, and a prematurely liquid phase sintered product would be obtained with local grain growth occurring.

Felton et al. disclose a method of preparing tungsten carbide that involves treating finely divided tungsten trioxide with carbon monoxide (CO), so that carbon activity is infinity. Deposition of free carbon is expected to compete with the carburization, although this is not described in the reference. At page 1, line 23, Felton et al. disclose the following formula:



It is asserted in the Office Action that this step somehow corresponds to the heat treatment of step (b) in Claims 10 and 16, and one skilled in the art would be motivated to use higher temperatures to further carburize the tungsten. Applicants respectfully disagree with these assertions. Since Felten does not describe the use of a CO₂/CO mixture, and does not describe a two-step process to prepare tungsten carbide, it says nothing to one skilled in the art about how to achieve the high-quality tungsten powders of the present invention by means of the claimed two-step process. As noted above, the carburization step described in Felten will result in deposition of free carbon, which is avoided in the present invention.

The invention as a whole must be considered when evaluating patentability, as set forth in *Stratoflex, Inc. v. Aeroquip Corp.*, 713 F.2d 1530, 218 USPQ 871 (Fed. Cir. 1983); and *Schenck v. Nortron Corp.*, 713 F.2d 782, 218 USPQ 698 (Fed. Cir. 1983); MPEP 2141.02. None of the cited references, alone or in combination, teach a two-step process of preparing tungsten carbide having the desired properties, the process including the steps of carburization in a CO₂/CO atmosphere, followed by a further heat treatment step. None of references remotely suggest that a heat treatment step will stabilize the tungsten carbide against grain growth in hard metal production.

Applicants submit that Claims 10 and 16, and dependent claims 11-14, are not obvious in view of the cited references. Withdrawal of the §103 rejection is respectfully requested.

SUMMARY

As all outstanding issues have been addressed, Applicants respectfully submit Claims 10-14 and 16 are in condition for allowance; such action is respectfully requested at an early date.

Respectfully submitted

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